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1. Microscopic Theory of Cyclotron Resonance

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1. Microscopic Theory of Cyclotron Resonance

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2. DNA 二重らせんと水和水

— 低振動数ラマン散乱 —

小 川 恵

1. Microscopic Theory of Cyclotron Resonance

Hiromi Ezaki

Abstract

The well known phenomenon called "cyclotron resonance" can be observed when an electromagnetic wave is applied to such materials like semiconductors in a static magnetic field. Cyclotron resonance experiments provide much information about electronic states in solids.

In the first half of this thesis a historical development of quantum theory of cyclotron resonance is reviewed, and subsequently a new formalism of the resonance theory is formulated on the basis of the damping theory.

In this thesis electron-electron interaction is neglected, and the single-particle approximation is used. And for the sake of simplicity it is assumed that all electrons are possessing the same spherical effective mass. The scattering with impurities is taken into account, which distribute completely random. Furthermore the electron system is assumed to be under the influence of a static uniform magnetic field.

The pioneering work of Miyake(1964) is based on a formalism due to Kubo, Miyake and Hashitsume who made explicit calculations of static admittance in a strong magnetic field. Utilizing a stochastic theory

developed by Kubo, Miyake derived an expression for the dynamical admittance.

In 1967 Kawabata presented another approach which utilized Mori's method of Langevin equation. His important assertion is that the absorption linewidth should be regarded as the inverse of the relaxation time for the electronic current. It should be pointed out also that a certain *ad hoc* averaging procedure of impurity scattering is found in his calculations.

Shin, Argyres and Lax(1972) obtained self-consistent equations for the "linewidth" and the "frequency shift" with the use of damping iteration method. As for the configuration average, certain unsatisfactory features are found also in their work.

Using a diagram expansion technique Prasad obtained infinite number of coupled equations for the "linewidth" and the "frequency shift". His result, however, seems to hold in dilute limit. Furthermore Prasad did not solve the coupled equations.

In this thesis an expansion formula for time correlation functions is given with the use of damping theory. The system (composed of electrons) is influenced by a heatbath (phonons, impurities, etc.). Only the relevant information of the system is necessary. Such a contracted description is performed with the use of Mori's projection operator \mathcal{O} :

$$\mathcal{O} G(t) \equiv \frac{\langle G(t) J_+ \rangle}{\langle J_- J_+ \rangle} J_- ,$$

where $J_{\pm} \equiv J_x \pm i J_y$, J_x and J_y are the x- and y-component of the current operator respectively ; $\langle \rangle$ denotes the average over the grand canonical distribution for the total Hamiltonian and the impurity distribution, and $G(t)$ is an arbitrary operator whose time evolution is governed by the total Hamiltonian. With the use of a formula (TC formula) of the damping

theory, an expansion formula is obtained for the current-current correlation function. The conductivity tensor is calculated as the Fourier-Laplace transform of the current-current correlation function to give the absorption spectrum.

The absorption spectra are numerically calculated for two- and three-dimensional electron systems within the second order approximation of the impurity potential. The relating potential is assumed to be Gaussian. Since in existing works numerical calculations for the explicit form of absorption spectrum have been performed so rarely, our calculations are considered to be important.

Our method has a quite satisfactory feature : a direct calculation of the correlation function can be performed without the use of the regression theorem. Furthermore owing to this method the average over random configurations of the impurities can be performed rigorously. In this thesis our consideration is restricted to the second order of the perturbation. However it may be possible to renormalize higher order terms with a resummation technique like CPA, since higher order terms can be calculated systematically.

2. DNA二重らせんと水和水 —低振動数ラマン散乱—

小 川 恵

Abstract

Recently it has been of great interest to study the dynamical properties of the molecular assembly of DNA double helix in connection with the hydrated water, because the hydrated water around DNA affects strongly not only the local conformation of the double helix but also the